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The PSYCHOLOGICAL RECORD . . . .

JUNE, 1941
Vol. IV No. 20

MOTOR FUNCTION IN THE MENTALLY DISORDERED—PART I

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THE PRINCIPIA PRESS, INC.
BLOOMINGTON, INDIANA

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MOTOR FUNCTION IN THE MENTALLY DISORDERED*

I. A COMPARATIVE INVESTIGATION OF MOTOR FUNCTION IN PSYCHOTICS, PSYCHONEUROTICS AND NORMALS[1]

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Introduction

Trained observers have long been aware of differences in motor function among psychotics, psychoneurotics and normals. The inability to state these differences in quantitative terms has not destroyed the belief that they are significant modifications resulting from the disease process. There are many elements in the patient's behavior to account for the persistence of this idea. Clinical experience has shown that the psychoses generally involve a reduction of energy output, energy used inappropriately and out of proportion, an inadequate or inappropriate affective response, a reduction of interest in the environment and an acceleration of fantasy life. The means of adaptation of the organism have in some way been modified to the point where adequate adjustment becomes impossible. Certain types of investigation of this inadequacy of reaction have not been wanting in the past. Many psychological levels of adjustment have been investigated. This is true in the case of motor function as well as in other fields, but the attempts at the accumulation of accurate information about psychotic modes of motor adaptation have not been characterized by any semblance of systematization until very recent times.

As early as 1904 Hoch (17) reviewed the experimental work

* Recommended for publication by Dr. E. S. Conklin, April 24, 1941.

[1] The first of a series of three studies presented to the Faculty of the Graduate School of Yale University in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Psychology, 1938. The writer desires to express his indebtedness to Professor Walter R. Miles under whose direction this study was carried out.

done in connection with the study of mental diseases. He reports early studies on the knee-jerk and on Kraepelin's writing balance, along with the ergographic studies of Kraepelin and Hoch. Differences between psychotics and normals are reported, but because of the infancy of scientific method in psychological work, these early studies were without adequate controls, population sampling or statistical measures of reliability. Notwithstanding these omissions, the results were generally accepted as valid. Kraepelin, Hoch asserts, was the pioneer in this field. Since that time a considerable quantity of experimental investigation has been done, but nothing approaching a systematic, comprehensive research has been undertaken. Research germane to the problem has been done by Barnacle, Ebaugh and Lemere (2), Bevan-Lewis (5, 6), Boring (7, 8), Franz (14, 15), Gatewood (16), Huston (20), Lundholm (24), Mays (25), Saunders and Isaacs (30), Scripture (31), Shakow (35), Shipley (36), Wells (37, 38), Wells and Kelley (39), Wiersma (40), and Yerkes (43). Hunt (18) in an exhaustive review of the literature, brings the historical background of the problem up to 1934. Partial repetition of that work would be pointless here. However, since the date of his review several reports have appeared presenting evidence of the beginning of systematic investigations, especially at the levels of simple motor function, notably the studies in schizophrenia at the Worcester State Hospital. Brief abstracts of this work follow.

Shakow and Huston (34) investigating the speed of tapping in 123 schizophrenics, 13 manic-depressives, and 60 normals found that schizophrenics gave significantly lower mean scores and showed greater variation than did normals, although they became less variable from session to session. Age, education and occupational levels, time of day and duration of the psychosis appeared to have little effect upon the differences. They concluded that the differences are probably attributable to the effect of attitude or cooperation. The experiment presented some evidence in favor of the schizophrenic diagnostic type differentiation.

The second in the Worcester series was a study of reaction time. Huston, Shakow and Riggs (19) examined simple auditory, simple visual and discrimination visual reaction times in 38 adult male patients and 25 normal adult male control subjects. They

report that the patients gave significantly longer mean times and greater group and within-individual variation than the normals. This also held true for a group of patients selected from the total group on the basis of cooperation. The cooperation of the selected group and that of the normals was approximately equivalent. Results were contrary to the belief expressed in the first study that cooperation or attitude might account for the differences between the patients and the control group. Three hypotheses were advanced to account for the speed differences. These hypotheses involved the level of preparation attained and the consistency of maintaining the level. A second experiment was planned to test the hypotheses. It was found that patients do not attain as high a level of preparation as normals, that patients vary more within themselves, in the height of preparation attained from reaction to reaction, and that they do not maintain their level of preparation as consistently as the normals.

Two Russian workers, Dozenko and Fatova (10), using the methods of Oseretsky (28), i.e., the application of Oseretsky's age scale for the determination of motor maturity in children, showed that speed, simultaneous movements, time and rhythm are the maximally decreased components of motor function in schizophrenic children.

These three researches complete the list of work bearing directly upon the problem at hand. There have been a large number of studies on various aspects of motor function in normals, and a few among the mentally deficient, but without direct application to the present investigation and therefore they will not be reviewed here.

In the present investigation the point of view is derived from the concept of diagnostic group differentiation and the similarities and differences which may be found among such groups. The approach is somewhat different from that of previous investigators, as will be seen in the statement of the problem which follows.

The Problem

The object of the present investigation was to explore one aspect of the very broad problem of the ways in which mental disorder alters the individual's capacity for performing adaptive acts in the

motor sphere. The aim was to make possible the expression of such changes in quantitative terms as opposed to the rough differentia of observational judgments. It is not expected that the experimental method will supersede clinical observation but rather that the two methods will supplement each other. Experiment should help toward a finer analysis of the differences observed by the clinician and hence should become an important adjunct in the field of diagnostics. Woodworth (42) made clear these hopes as far back as 1906, and the optimistic Scripture (31) believed that certain forms of motor tests could, when perfected, become a means for absolute differential diagnosis. In the opinion of the writer it is not enough, if we are to achieve his ideal, to compare one group of patients of like symptoms with a normal control group. To be sure, a control group is necessary as a point of reference but the problem of differentiating between the various types of mental disease can best be met by a direct comparison of the several types one with another. For that reason the two major psychotic types, namely, manic-depressive and schizophrenic, were subjected to the same situations and tests as psychoneurotics and normals in such a manner as to produce comparable data. Other patient group combinations are possible and should be investigated with the same techniques.

Without intending to minimize the influence of the verbal and affective factors the point of view of this study regards motor function as one of the essential underlying mechanisms determining the adequacy of the adaptive acts by which the individual adjusts to his intricate environment. The degree of adequacy in performing both simple and complex adaptive acts is one among the several criteria applied by the clinician in making his judgments when diagnosing patients and is therefore to be construed as a component part of the complex we call personality, whether it be normal or psychopathic.

By administering seven relatively unrelated tests of motor function designed to sample adaptive acts at the intermediate levels of integration, to groups of psychotic, psychoneurotic and normal persons, this investigation sought to establish by statistical analysis and comparison the reliability of the obtained differences in the performance of these groups.

By "intermediate levels of integration" is meant those movements dependent upon the execution of a series of simple, non-identical, sequential coordinations or elements of movement linked together into patterns involving both preparation to respond and sustained activity of short duration. Movements of this type may be contrasted with the unitary uncomplicated activity of simple reaction time responses, knee-jerk reflexes, or the speed of tapping at the lower levels and the intricate combinations of movements at the higher levels. An example of the latter type of response would be the complicated reaction patterns necessary in driving an automobile. The definition of the phrase is therefore behavorial and does not imply dependence upon neurological processes in terms of the combination and organization of neural excitations although such processes are known to be involved. The complicated problem of levels of neural integrations is beyond the scope of the study reported here.

We may now turn to a consideration of the subject population selected for the investigation.

Subjects

It has never been a simple matter to secure large groups of psychiatric patient subjects for experimental purposes. Moreover the difficulties of working with disturbed people are not easily overcome. Infinite patience and tact are essential. For these reasons, and perhaps others, many investigations in experimental psychopathology have suffered from a paucity of subject material. The present investigation has tried to overcome this criticism by enlisting patient groups large enough to give statistical reliability to the measures.

All subjects used were white, male adults. The patient groups chosen were composed of 25 psychoneurotics, 23 schizophrenics, and 25 manic-depressives.[1] The control group of 50 subjects was made up of 35 students from the Yale Divinity School and 15 graduate students chosen from among the various schools in the Yale Graduate School. The divinity students were paid for their

[1] There were to have been 25 subjects in the schizophrenic group. Conditions beyond the control of the writer made the completion of this group impossible.

services. The graduate students were not paid.

The necessity to equate the control group as nearly as possible for age, homogeneity, intelligence and previous specialized training which might have given the control group advantages in motor skills over the patient population, led to the selection of this particular group of divinity and graduate students from among the few possible groups available.

Table (1) gives the data for age range comparison. Table (2) shows the way in which the patient population was diagnostically sub-classified.

Under the present somewhat confused condition of diagnostic techniques, control of this variable cannot be very accurate even under the most careful conditions. Adequate diagnosis eventuates from the scrutiny of a longitudinal section of the patient's life rather than a cross sectional one. To eliminate as much hazard as possible in the selection of the various members of the patient groups, only those subjects were chosen on whom the diagnosis was clear-cut and undebated in the record of the diagnostic clinic. For the most part the patients chosen had been under observation for an extended period of time. Many of the patients had been diagnosed more than once. Patients of an "indeterminant" sub-classification were generally not selected for the experiment. In the case of several of the so-called "simple schizophrenic" subjects, there had been a previous sub-classification diagnosis of "indeterminant" but this diagnosis had, after more extended observation, been changed to "simple".

TABLE I

AGE DISTRIBUTION IN YEARS FOR THE VARIOUS MALE GROUPS USED

Subject groups	N.	Maximum	Minimum	Range	Mean	S. D.
Normals	50	54	19	35	29.3	4.44
Schizophrenics	23	47	19	28	29.5	7.51
Manic-Depressives	25	54	22	32	36.1	9.61
Psychoneurotics	25	52	24	28	32.4	8.69

TABLE 2

THE FREQUENCY OF DIAGNOSTIC SUB-CLASSIFICATIONS FOR THE VARIOUS GROUPS USED

Schizophrenics	Simple	Hebephrenic	Catatonic	Paranoid
23	8	4	4	7
Manic-Depressives	Manic Phase	Depressive Phase		
25	8	17		
Psychoneurotics	Anxiety States	Homosexuality	Behavior Problems	Alcoholism and Drugs
25	7	3	3	12

Among the psychoneurotic group those subjects with neuroses related to alcoholism were chosen only when the primary diagnosis was plainly "psychoneurosis" with accompanying "alcoholism" as a secondary factor, i.e. when the alcoholism was not regarded as the basic disorder of the personality but rather as symptomatic and secondary.

In any experimental study of adaptive acts such as those involved in this investigation, the necessary prerequisites include ability and willingness of the subject to cooperate. These factors act as limiting or selective elements in sampling the patient population, ruling out a considerable proportion of the classes to be tested, but they are factors not amenable to control. Sixteen subjects were tried in the test situation, but could not be used because of inability to cooperate or complete the whole test battery.

Estimated level of patient intelligence did not have any close bearing upon the efficiency of the individual to perform motor tasks; hence, the variable was allowed to operate as freely as possible within the group from which the selection was to be made. It so happened that all the patient subjects chosen had a rated I.Q. of 100 or better, with the exception of 2 schizophrenics who were probably borderline in intelligence. Approximately 85% of the patient subjects were college men.

Patients whose case records indicated the presence of any physical disabilities such as visual or auditory defects, paralysis, or muscular atrophy etc. were not included in the experimental population.

Another selective sampling factor was operative due to the fact that the Hospital in which the study was made is a private institution requiring relatively high fees as compared to the ordinary State Hospital. Hence there was present a socio-economic level selection operating in the choice of the total patient population of the institution.

Presumably this selection tended to give a population which in general had had less specific motor skill training than might be found among the predominantly working-class populations of most state institutions.

Tests, Apparatus and Procedure

General Considerations: Consideration of the problems of motivation involved in the participation of mental patients in experimental examinations or testing situations leads into a maze of unfathomable complexity. To control motivation completely in human subjects is next to impossible at our present stage of psychological knowledge. Attempts at limitation seem to offer the only possible method with which to attack the problem when control becomes necessary.

In attempting to limit the motivational factors operating in this experimental set-up, the procedure followed was to utilize the routine testing situation in the hospital for experimental purposes. Patients who, in the ordinary course of routine examination, were referred to the psychological clinic participated in the experiment as a part of the routine testing program. They were brought to the clinic by a nurse or psychiatric aide with the understanding that they were to have a general psychological examination. Knowledge of what the tests would involve was not available to the patient except as it was passed about in the halls or cottages. In any case, none of the subjects or their nurses knew that a part of the examination would be experimental. Thus the attitudes and motivation factors were those ordinarily common to the routine life of the hospital.

In the test situation, an attempt was made to standardize all instructions. Adherence to the standard instructions was, however, rarely possible, as anyone who has worked with mental patients will readily understand. Even though deviation was nec-

essary, it was far less than expected, and centered mostly around the need to urge the depressed subjects to continue, or bring the distractible schizophrenics and manics back to the task at hand.

Patients who developed an inability to cooperate during a test session were immediately removed. Only three subjects attempted to mutilate or destroy parts of the apparatus. On the other hand, many of them tended to make a game of the tests. Members of the psychoneurotic and normal groups never required deviation from the formal instructions.

Test room conditions were satisfactorily controlled for light, temperature and equipment. There was no furniture in the room except the test table and two chairs. The tests were presented in such a way that only the apparatus for the test in use was visible to the subject. The recording apparatus was located in an adjoining room. The humming sound produced by the polygraph motor was minimized by the housing around the instrument, and by the wall separating it from the testing room. The sound was faintly audible in the test room but could scarcely be distinguished from the usual sounds in the building. None of the subjects indicated an awareness of the sound.

Other disturbing elements to be mentioned were the spark occasionally produced when the stylus of the star tracing apparatus was held close to the star, but not in contact with it, and the humming sound produced by the Cenco timing device used on the Miles Reaction-Coordination board. These proved a source of annoyance to three of the schizophrenics and two psychoneurotics.

All tasks were presented to all subjects in the same order. The number and length of the experimental sessions, three thirty-minute sessions on consecutive days, were kept at the lowest possible time consonant with reliably adequate results. This was necessary in order to reduce possible diminution of interest, fatigue and practice effects, and the possible increase of excitability in some of the patients due to the strain of the test situation.

Tests 1 and 2. Estimation of Known Sizes: Dollar Bill and Fifty Cent Coin

Estimation of known sizes was first used by Wolfe (41) as a test of motor judgment. More recently Allport and Vernon (1) and Eisenberg (11) have made use of the test in studying intra-

individual consistency of personality. This study has followed the techniques of Allport and Vernon. Test 1: the estimation of the size of a dollar bill (current U.S.) by drawing the rectangle judged to be the actual size of the bill. Test 2: the estimation of the size of a half dollar coin (U.S.) by drawing the circle believed to approximate most clearly the real size of the coin.

Procedure: At the beginning of each of the three sessions, the subject was given sheets of paper 8½ x 11 inches, and told to draw, on separate sheets, a circle the size of a half dollar coin and a rectangle the estimated size of a dollar bill. Neither ruler nor compass were used.

The drawing of the rectangles and circles was seldom regular so that in measuring these areas for scoring, the method of Allport and Vernon was followed, i.e. the longest diameter was found, and this was multiplied by the length of the diameter perpendicular to it which passed through its middle point. Measurement was in centimeters.

Test 3. The Pneumo-ergograph

The third test utilized a modified ergographic work task. Insofar as motor skill and coordination complexity are involved, this test is the most simple in the battery and has not been regarded as measuring motor skill, although it may be considered as very closely related to motor skill phenomena. It is regarded as being an important aspect of motor function in that it measures the work and fatigue components operating in simple manual manipulations of an extended type.

Robinson (29) has pointed out that the work decrement is one of the basic facts of behavior. Yockelson (unpublished) studied the work decrement curves of certain groups of the mentally ill and found a differential function in the work curves obtained. The reliability of his results is not known.

The present study used the work decrement type of phenomenon as a simple measure of difference between the tested groups without reference to the theoretical problems of interpretation involved in it. These have been presented elsewhere (29). The writer was not so much interested in the qualitative aspects of the curves obtained from the several groups as he was in the fact that the

curves did differ from each other and to what extent they differed. For this and other reasons the within-trial analysis of the function was not made. Rather, the means of each of 3 trials within a session were plotted for the purpose of measuring differentiation.

Because it is often impractical, in working with psychotic subjects, to use an instrument which necessitates strapping the subject to the apparatus, a simpler method had to be devised. The method adopted was to have the subject squeeze a soft rubber bulb as rapidly as possible during a stated interval of time. This type of apparatus was first reported by Barker (3).[1]

Procedure: Subjects were asked to take the bulb in their preferred hand and squeeze it as rapidly as possible in order to see how high they could pump the water in the visible manometer gauge and maintain the level attained. After a demonstration by the experimenter and a trial by the subject the signal "ready—go" began the real test. At the end of ten seconds, measured by a stop watch, the subject was told to stop. The first work interval was followed by a ten second rest interval. The test was repeated a second and third time during each session. Before the succeeding test was begun the subject was permitted a five-minute rest interval.

Test 4. Star Tracing

Simple forward star tracing is a motor task involving coordination, steadiness, speed and accuracy of movement. The test lends itself easily to the present problem and can be scored by relatively simple criteria, namely speed of performance and errors made. The apparatus consisted of 5 concentric stars set in a Bakelite panel, 23 x 23 cm., and a brass stylus with a wooden handle. When the stylus touched any of the stars an electrical circuit was completed which recorded on a polygraph.

Procedure: The star and stylus were presented by placing them immediately in front of and facing the subject appromixately twelve inches from the edge of the table. The subject was per-

[1] This and the other apparatus used in the experiment are fully described in the dissertation deposited in the Sterling Memorial Library, Yale University.

mitted to pick up the stylus and hold it in any way most comfortable to him, so long as his fingers did not rest on the metal rod.

He was told, "This is a test to see how fast you can trace around the middle star ('this one'), beginning here at the top and finishing at the same place. You may try it. If you let the point slip off the middle star you will touch one of these to the right or left of it and that will be counted as an error. You are to work as fast as you can trying not to make mistakes. When you are told to begin, place the stylus at the top of the star and trace around it as fast as you can. As soon as you come back to the starting place take the stylus off the star. You will have three trials. Do you understand what you are to do? Ready—go." A one-minute interval was permitted between each trial.

Test 5. Reaction-Coordination (Miles)

Speed of motor reaction and coordination may be tremendously important in the performance of adaptive acts by which the individual adjusts to his environment. The accomplishment of any given coordination is dependent upon many factors both objective and subjective which cannot be experimentally controlled. Nevertheless an individual can be tested in such a way as to give a general impression of his personal tempo. This general factor of reaction-coordination speed as measured by the Miles technique readily met the criteria set for the tests in the present battery. The apparatus was designed by Dr. Walter R. Miles and utilizes the Cenco impulse counter.

Procedure: The technique for the "reach and grasp coordination" (pencil shifting) described by Miles (27) was used for the preferred hand alone since it is with this hand that the burden of manipulative acts are accomplished.[1] The problem of laterality of the subjects was not pertinent to the study and would un-

[1] In this test the subject is instructed to place his preferred index finger on the key and hold it down. Whenever ready he is to release the key, reach with his preferred hand to the pencil, lift it from the hole and place it in the hole nearby, then return his index finger to the key and depress it to stop the clock. At the moment he releases the key the timer begins, when he depresses it time stops. The measurement is read directly from the clock readings before and after the coordination.

necessarily extend the time involved in completing the test, an expenditure avoided whenever possible.

Ten trials were given at each session and the means of the ten trials were computed as a basis for scoring.

Tests 6 and 7. Rhythm Patterns

The judgment of personal tempo and rhythm in the performance of motor acts is a common practice in daily life and yet rhythm appears to be an unanalyzable factor, describable only in terms of certain objective characteristics of movement. The word is best used as an adjective rather than as a noun since it describes relations of activity but has no existence in itself. Use of the word as a noun leads to nothing explainable while as an adjective it becomes more meaningful in terms of definition.

Despite our inability to make concrete the conceptualized notion of rhythm it was felt that the objective characteristics which are used in describing rhythm, i.e. speed, regularity, amplitude, repetition, perseveration and delay of movement, would provide several reliable measures for the comparison of motor function at the intermediate levels of integration. The four categories (a) delay, (b) perseveration, (c) number of taps made in following a pattern, and (d) the pressure time of the taps were finally chosen as objective measures of this function.

There were three parts to the apparatus. First, a standard telegraph key ordinarily used in psychological laboratories as a responding instrument; second, a standard telegraph sounding device as the stimulus producer, and third, a motor driven table type make-break switch for patterns of contact used to activate the sounder.

Procedure: The telegraph key was placed on the table directly in front of the subject. None of the other apparatus was visible. He was told, "This is a test to see how quickly you can respond to some sounds by touching this telegraph key. Here are the sounds." Each of two patterns was run through completely. "In the real test you must listen carefully for these same sounds and when you hear them tap this key. Try to follow each sound as quickly as you can. Try to get the rhythm of the sounds and tap it out on the key. You will have three trials on each of the two patterns you have just heard. Each trial will have a regular pattern

first and the irregular one following it. Do you understand what you are to do? Ready?"

When the instructions were understood by the subject, each pattern was presented three times alternately with a ten-second rest interval between the presentation of the patterns. Only a few subjects failed to understand the instructions. In a case like this, the instructions were repeated as first given.

All responses were recorded on a 12 inch, constant speed, portable polygraph.

Results and Conclusions

Because of the variety of the groups tested and the number of tests administered the best way to present the results is to treat each test as a separate unit and compare the results of each group on each of the tests. Tables comparing the data for the distributions of the means of each group on the individual tests are given, indicating the differences from trial to trial and session to session. In this manner the data can be more readily assimilated.

Test 1. The Estimation of Known Sizes. The Dollar Bill.

Allport and Vernon (1) and other investigators (11), (41) have shown that normal subjects have a characteristic way of underestimating the sizes of known rectangular objects. In their test for drawing the dollar bill they report extremes of estimation running from the maximum of 110.5 to a minimum of 34.4 sq. cm. with a median area of 75.1 sq. cm. Most of the subjects in this present investigation consistently underestimated the actual area which is 103 sq. cm.

Table 3 gives the distribution of the mean scores for the four groups and presents the means for the three sessions. In Tables 5, 6, 7 will be found the critical ratios of the differences between the means of the various groups, and in Table 4 the coefficients of test-retest reliability (uncorrected) for all groups and all tests.[1]

[1] For convenience of comparison the coefficients of test-retest reliability have been grouped in tabular form in Table 4. Future reference to these reliabilities will be made without giving the table each time. The same holds true for the critical ratios of the differences, which appear in Tables 5, 6, 7.

TABLE 3

DATA OF THE DISTRIBUTIONS OF MEAN ESTIMATION OF KNOWN SIZES, TEST 1, THE DOLLAR BILL FOR VARIOUS GROUPS FOR THREE SESSIONS. (IN SQ. CM.)

Group	N.	Maximum	Minimum	Range	Mean	σm	S.D.	σs.d.	V.
Normals	50	121.40	44.11	77.29	81.56±	2.16	15.27±	1.53	18.72
Schizophrenics	23	92.87	37.14	55.74	64.09±	1.72	8.25±	1.22	12.87
Manic-Depressives	25	107.70	41.93	65.77	81.13±	3.18	15.88±	2.25	19.57
(a) Manics	8	107.20	71.37	36.33	87.04±	2.19	8.45±	2.11	9.71
(b) Depressives	17	105.60	41.83	63.67	78.36±	4.06	15.72±	2.69	20.06
Psychoneurotics	25	107.47	44.23	63.24	80.16±	2.66	13.03±	1.84	16.25

TABLE 4

COEFFICIENTS OF RELIABILITY — TEST-RETEST, MEANS OF SESSIONS II & III

(The correlations are Pearson Product Moment Coefficients of Correlation. All values are positive)

Test	Normals	Schizophrenic	Manic-Depressive	Psychoneurotics
N.	50	23	25	25
(1) Estimation of Known sizes—Dollar Bill.	.82±.03	.76±.06	.75±.06	.72±.07
(2) Estimation of Known sizes—Half Dollar.	.77±.04	.60±.09	.81±.05	.71±.07
(3) Pneumo-ergograph.	.48±.07*	.36±.12	.43±.11	.60±.09
(4) Star Tracing.				
(a) Time	.94±.01	.83±.04	.93±.02	.91±.03
(b) Errors	.84±.03	.75±.06	.82±.04	.85±.04
(5) Reaction-Coordination.	.74±.04	.58±.09	.89±.03	.82±.04
(6) Rhythm-Regular Pattern.				
(a) Delay	.81±.03	.92±.02	.93±.02	.91±.02
(b) Perseveration	.50±.07	.80±.05	.76±.06	.78±.05
(c) Number of Taps	.92±.01	.55±.09	.92±.02	.73±.06
(d) Pressure Time	.86±.02	.47±.11	.74±.06	.69±.03
(7) Rhythm-Irregular Pattern.				
(a) Delay	.79±.03	.87±.04	.92±.02	.90±.03
(b) Perseveration	.55±.06	.83±.04	.67±.07	.17±.13
(c) Number of Taps	.83±.03	.76±.06	.79±.05	.72±.07
(d) Pressure Time	.83±.03	.41±.11	.76±.06	.75±.06

* Summation of trial 2 for the 3 sessions correlated with summation of trial 3 for the 3 sessions gave a coefficient of reliability on this test of .85±.03. The same for trials 1 & 3 gave a coefficient of reliability of .71±.03.

TABLE 5

RELIABILITY OF THE DIFFERENCES ($\frac{D}{\sigma D}$) BETWEEN MEANS OF THE MEANS OF THE NORMALS AND PATIENT GROUPS ON ALL TESTS

Test	Schizophrenic	Manic-Depressive	Manic	Depressive	Psychoneurotic
N.	23	25	8	17	25
(1) Estimation of Known sizes—Dollar Bill.	6.37	.11	1.78	.70	.41
(2) Estimation of Known sizes—Half Dollar.	2.80	1.87	.42	2.57	.06
(3) Pneumo-ergograph.	6.90	3.46	.91	4.16	.84
(4) Star Tracing.					
(a) Time	4.90	.57	4.22	1.79	.51
(b) Errors	2.19	1.89	3.56	.09	1.44
(5) Reaction-Coordination.	5.50	1.60	.68	5.88	.59
(6) Rhythm-Regular Pattern.					
(a) Delay	6.54	.13	3.75	1.26	.26
(b) Perseveration	.63	1.21	1.57	4.23	.08
(c) Number of Taps	1.65	1.02	3.84	.51	.77
(d) Pressure Time	4.00	.73	3.01	2.50	.21
(7) Rhythm-Irregular Pattern.					
(a) Delay	1.91	2.56	5.83	1.69	.53
(b) Perseveration	.92	2.71	1.10	3.02	.30
(c) Number of Taps	2.96	.30	2.31	2.54	.63
(d) Pressure Time	4.80	.25	.53	3.58	.19

TABLE 6

RELIABILITY OF THE DIFFERENCES ($\frac{D}{\sigma D}$) BETWEEN THE MEANS OF THE MEANS OF THE SCHIZOPHRENIC GROUP AND THE THREE PATIENT GROUPS ON ALL TESTS

Test	Manic-Depressive	Manic	Depressive	Psychoneurotic
N.	25	8	17	25
(1) Estimation of Known sizes—Dollar Bill.	4.71	8.26	3.24	5.07
(2) Estimation of Known sizes—Half Dollar.	.29	2.04	.66	2.26
(3) Pneumo-erogograph.	3.67	3.59	2.86	6.00
(4) Star Tracing.				
(a) Time	3.35	9.47	1.61	2.52
(b) Errors	.66	.92	1.29	3.23
(5) Reaction-Coordination.	8.33	4.63	8.89	5.83
(6) Rhythm-Regular Pattern.				
(a) Delay	1.65	5.29	.37	2.03
(b) Perseveration	1.55	.76	3.25	.51
(c) Number of Taps	3.88	6.54	1.11	.31
(d) Pressure Time	.45	6.12	1.48	.71
(7) Rhythm-Irregular Pattern.				
(a) Delay	1.62	4.42	.00	1.73
(b) Perseveration	.60	1.56	1.43	1.13
(c) Number of Taps	2.32	4.04	1.10	1.92
(d) Pressure Time	1.20	.93	.14	.64

TABLE 7

RELIABILITY OF THE DIFFERENCES ($\frac{D}{\sigma D}$) BETWEEN THE MEANS OF THE MEANS OF THE MANIC-DEPRESSIVE AND THE PSYCHONEUROTIC GROUPS ON ALL TESTS

Test	Manics & Depressives	Manic-Depressive & Psychoneurotic	Manics & Psychoneurotics	Depressives & Psychoneurotics
N.	8-17	25	8-25	17-25
(1) Estimation of Known sizes—Dollar Bill.	1.88	.23	2.00	.37
(2) Estimation of Known sizes—Half Dollar.	2.35	1.69	.84	2.44
(3) Pneumo-ergograph.	1.62	2.54	.42	3.25
(4) Star Tracing.				
(a) Time	4.32	.08	2.66	.91
(b) Errors	2.43	3.06	4.54	2.10
(5) Reaction-Coordination.	4.12	1.36	1.00	1.75
(6) Rhythm-Regular Pattern.				
(a) Delay	3.87	.34	2.93	1.36
(b) Perseveration	4.32	1.42	1.43	4.33
(c) Number of Taps	4.56	1.54	3.57	.40
(d) Pressure Time	3.64	.48	.31	1.25
(7) Rhythm-Irregular Patterns.				
(a) Delay	4.00	.82	2.26	1.66
(b) Perseveration	6.19	3.90	1.04	3.23
(c) Number of Taps	3.72	.30	2.48	1.23
(d) Pressure Time	.59	.32	2.75	.41

TABLE 8

TEST INTERCORRELATIONS AND PROBABLE ERRORS, NORMAL GROUP

(Pearson Product-Moment Coefficients of Correlation)

	1	2	3	4(a)	4(b)	5	6(a)	6(b)	6(c)	6(d)
1 E.K.S. Dollar Bill	——	.15±.09	.22±.09	—.22±.09	.22±.09	.05±.10	—.25±.09	.09±.09	.32±.09	.04±.10
2 E.K.S. Half Dollar		——	.12±.09	.11±.09	.10±.09	.19±.09	—.08±.09	.33±.08	.25±.09	—.36±.08
3 Pneumo-ergograph			——	—.09±.09	.19±.09	.05±.10	—.28±.09	.01±.10	.13±.09	—.20±.09
4(a) Star Tracing Time				——	.45±.08	.33±.08	—.01±.10	.03±.10	—.10±.09	—.14±.09
4(b) Star Tracing Errors					——	—.05±.10	—.03±.10	.05±.10	.17±.10	—.13±.09
5 Reaction-Coordination						——	—.11±.09	.07±.10	.08±.10	.06±.10
6(a) Rhythm Reg. Pattern, Delay							——	.15±.09	—.65±.05	.27±.09
6(b) Rhythm Reg. Pattern, Perseveration								——	.48±.07	.22±.09
6(c) Rhythm Reg. Pattern, Number of Taps									——	—.07±.10
6(d) Rhythm Reg. Pattern, Pressure Time			——							

Reliability of this test for the four groups was fairly high, ranging from $r = .72 \pm .07$ for the psychoneurotics to $r = .82 \pm .03$ for the normals. The reliability for the normal group is quite satisfactory and the others well within satisfactory limits since the number of cases is known to influence this factor. The application of the Spearman-Brown formula as a correction would probably raise the coefficients considerably, but since in most of the tests the reliabilities are rather high it was deemed unnecessary to apply this correction especially since it implies certain statistical conditions which are not always fulfilled by data of this type. The raw reliabilities are therefore used because they probably express more accurately the psychological nature of the results obtained.

From Table 3 it may be noted that not all of the patient groups show significant differences in underestimation of known rectangular sizes. The widest spread in this ability occurs between the normals and the schizophrenics, the latter underestimated the area far below any other group. The critical ratio ($D/\sigma D$) between the normals and the schizophrenics is 6.37. Wide differences also occur between the schizophrenics and the other patient groups, all of which were highly significant.

When the manic-depressive group is taken as a whole the differences between them and normals become negligible. By breaking down the group, i.e., considering the manics and the depressives separately, a procedure which is justifiable on the basis of the marked symptomatic differences, the data show more striking results![1] The difference between the manics and the normals, while not so marked as the schizophrenics, indicate 96 chances in 100 of a reliable difference. This group was the only one which succeeded in estimating the actual size more closely than the normals. While there is an apparent difference between the psychoneurotics and the normals it is not to be considered as reliable.

[1] Because of the small number of cases in each group, i.e. 8 manics and 17 depressives, the possibility of applying Fisher's T formula for the reliability of the differences, in order to obtain more reliable comparisons, was considered. A trial application on one sample demonstrated that the longer method did not justify its use for these data since the critical ratio was changed by not more than .05. Since this difference is not statistically significant the simpler method $D/\sigma D$ was applied with Student's correction for the small number of cases.

Rhythm Reg. Pattern; Pressure Time

Comparing the patient groups it becomes apparent at once that schizophrenics perform this kind of memory judgment in an entirely different manner than the manics. The reliability of the difference between the two groups is 8.26. It is also true that depressives and manics give differential estimations of known sizes. It will be observed that the curve of performance for all groups is roughly similar except for the manic group who underestimated the size more in sessions II and III than in session I. Psychoneurotics closely approximate normal performance on this test.

Improvement, i.e. progressively closer approximations to the actual size, regularly occurred from session to session. This holds true for all of the groups except the manics who showed a loss between sessions I and II and no improvement between II and III. The depressives, on the other hand, improved sharply from the second to the third day. With the exception of the schizophrenic patients whose improvement was consistent for all three days, the other groups improved more between days II and III than between I and II. The possible reasons for these differences will be discussed later.

Contrary to the results of other experiments (19, 34) these data, as judged from the standard deviations and the coefficients of variability, do not show the schizophrenics as consistently more variable than other patients or than normals from test to test. In test 1 the depressives showed the greatest variability, the manics the least, the manic-depressives as a group showed the second largest amount. The schizophrenic patients were less variable than the normals but more variable than the manics.

These results raise a nice question for further experimentation, i.e. does schizophrenia tend to produce stereotypy of behavior as has heretofore been supposed?

Test 2. Estimation of Known Sizes. Half Dollar Coin.

The intercorrelation between the estimation of the area of the dollar bill rectangle and the circle of the half dollar coin (Table 8) was found to be $r = +.15 \pm .09$. This low intercorrelation necessitates treating the two tests as relatively independent variables. The Allport and Vernon (1) data gave an $r = +.34$.

Test-retest reliabilities were slightly lower on this test than on test 1, but were well within the ranges of the earlier test. The

maximum $r = +.81 \pm .05$ for the manic-depressives, the minimum $r = +.60 \pm .09$ for the schizophrenics. For tests of this sort and especially with abnormal subjects these reliabilities may be regarded as fairly satisfactory.

Wolfe (41) observed that the estimations by normal subjects of the area of known circular objects were usually greater than the actual size. Allport and Vernon's subjects in estimating the area of a fifty cent coin (the actual area is 9.0 sq. cm.) overestimated it slightly, the median being 10.65 sq. cm. Reference to Table 9 will show that all of the means obtained in this investigation are above the actual size of the coin. Examination of the ranges, however, indicated that overestimation was by no means universal among the subjects in any of the groups. As a matter of fact, the depressives gave a mean estimation on session I which is well below the actual size of the coin. With the exception of the manic group on days I and II the patient groups tended to approximate the true size more closely than the normal.

Of more importance to this immediate study are the differences which obtain between the patient groups and the normals. Examination shows that the differences obtained on this test are not as wide as those on test 1 although they are in some instances close to complete reliability.[1] The difference between the schizophrenics and the normals and between the depressives and the normals closely approximate reliability. The manic-depressives as a group show a difference which has 97 chances in 100 of being reliable. Between the normals and the manics and the psychoneurotics the differences are only slightly better than chance with the exception of the manic's scores on the first day which are reliably different from the normals for that day alone.

When the schizophrenics are compared with the manics the chances are better than 98 in 100 of their being a reliable difference.

There are also 98.6 chances in 100 that the difference between the schizophrenics and the psychoneurotics is reliable. Since the psychoneurotics are closely identical with the normals the differ-

[1] Wherever the word "complete" appears hereafter in reference to the reliability of a difference ($D/\sigma D$) it is intended to mean that the critical ratio is equal to 3 or better.

TABLE 9

DATA OF THE DISTRIBUTION OF MEAN ESTIMATION OF KNOWN SIZES, TEST 2, THE HALF DOLLAR COIN—FOR VARIOUS GROUPS FOR THREE SESSIONS (IN SQ. CM.)

Group	N.	Maximum	Minimum	Range	Mean σ_m	S.D. $\sigma_{s.d.}$	V.
Normals	50	22.50	7.40	15.10	12.97± .59	4.16±.42	32.07
Schizophrenics	23	16.90	6.16	10.74	10.71± .55	2.63±.39	24.56
Manic-Depressives	25	19.23	6.47	12.76	11.04± .84	4.20±.59	38.04
(a) Manics	8	19.23	8.77	10.46	13.55±1.16	3.08±.77	22.73
(b) Depressives	17	18.33	6.47	12.36	9.86±1.06	4.12±.71	41.78
Psychoneurotics	25	21.43	6.50	14.93	12.15± .91	4.44±.63	36.54

ence is of little importance. However, this is the only test on which the difference approaches significance.

Comparing manics with depressives, there is a difference which has 99 chances in 100 of being completely reliable. Comparing the psychoneurotics with the manics, the depressives and the manic-depressives the chances in 100 of a reliable difference are 80, 99 and 96 respectively.

It is clear then that psychotic patients, in general, show significant differences in ability to estimate the sizes of known objects whereas the psychoneurotics tend to approximate the normal performance in this respect.

Inquiry concerning the intra-group, session to session changes in performance of this task leads to the observation that all of the groups increasingly overestimated the size from day to day although not in the same degree. The manics increased their estimations only slightly as opposed to the depressives who showed the most striking increase in overestimation between session I and session II. The normals and psychoneurotics give a curve approximating a straight line relationship whereas the manic-depressives and the depressive curves are negatively accelerated. The schizophrenic curve is positively accelerated. It must be remembered that the patient groups had no opportunity to examine the coin during the intervals between the sessions.

Again, on this test the schizophrenic group show less variability than the other groups except the manics. It would appear that if the schizophrenic performs at all he tends to show less variability in test results, but the chances of achieving enough rapport to get him to perform are much less than with the other groups. The question of variability from test to test will probably tell a different story. This will be discussed later (21).

Coefficients of variability (Table 9) for the groups show the depressives as most variable on this test, the manics the least. Manics and depressives together recorded the third most variability, psychoneurotics next and normals next. The variability of the normals may be due to the fact that the subjects had opportunity to examine the size of the coin between sessions although they were asked not to do so.

Test 3. Pneumo-ergograph

Considered in terms of levels of complexity this test sampled the lowest type of organized or coordinated activity of any of the tests in the battery. The simple task of squeezing a rubber bulb as rapidly as possible closely approximates tapping which Wells (38) found to give the finger ergographic type of response although it involved the use of a larger number of muscles. The finger ergograph restricts the muscles used to those of one or two fingers, as in the experiments of Benedict and Miles et al (4), whereas this task involved the muscles of four of the fingers. It is to be expected, therefore, that the scores on this test will in general be lower than those commonly gotten in ergographic work. The test, however, may be regarded as roughly comparable to the ergographic type of response.

Test-retest reliability for the means of session II with III was consistently low for this test. All values were positive, $r = .60 \pm .09$ for the psychoneurotics, $r = .48 \pm .07$ for the normals, $r = .43 \pm .11$ for the manic-depressives, and $r = .36 \pm .12$ for the schizophrenics. However, when the scores for the normals on trial 2 for the 3 sessions were summated and correlated with the summated scores of trial 3 for the 3 sessions r was found to equal $.85 \pm .03$. From these data one may assume that a quotidian factor was operating to give the low test-retest reliability which was not present in the situation between the trials on the same day. It is probable that the small amount of learning embodied in the test was maximal in the first trial and minimal in trials two and three. This notion is supported by the fact that the correlation between the summated scores of trial one for the three sessions when correlated with the summated scores of trial three in the three sessions gave a much lower index of relationship, $r = .71 \pm .03$.

The differences in performance between the psychotic patients and the normals were with one exception completely reliable. The $D/\sigma D$ for schizophrenics was 6.90, for manic-depressives 3.46 and for the depressives 4.16. In the case of the manics there were 82 chances in 100 of a reliable difference. The difference between the normals and the psychoneurotics was not reliable. Comparing the schizophrenic group with other patient groups the differences are completely significant in every case. Manics' scores as

compared with depressives have 94 chances in 100 of showing a reliable difference.

The qualitative aspects of the differences are interesting since in every case the psychoneurotics exceeded the performance of the normals although the difference was not statistically significant. All of the psychotic groups were below the performance of the normals, except on session three when the manics exceeded the normal performance. As reference to Table 10 will show, the schizophrenics were consistently far below all of the other groups in number of pressures in ten seconds. Their performance never approximated any other group's results. The depressives were next to the lowest in this ability. The manic-depressive group as a whole fell between the depressives and the normals. The difference between the manics and the normals was not notable except on the third day when they exceeded all other groups in number of pressures in the allotted time.

The nature of the curves obtained is roughly alike for all the groups. Two components appear in the results, (1) the decrement between trials within the same session appears as a straight-line function for most of the groups, (2) analysis of the means of the three trials for the three sessions gives a curve indicating a relatively consistent increase in the number of pressures from session to session. Hence the results show a rather consistent trial to trial work decrement on the one hand and a day to day improvement in rate of performance on the other. The same general relationships of the curves for each group were maintained from day to day.

It is to be noted that the psychoneurotics regularly show an increase in fatiguability from trial 2 to trial 3. A relatively sharp drop occurs in one other instance, namely, in the manic group during the first session. Had the psychoneurotic group included several patients diagnosed as neurasthenic, whose chief symptom is fatigue, the increase in fatiguability indicated by these results might be attributed to them. But there were none of this group so designated. Hence we cannot be sure that fatigue was a common symptom of this patient group and a determinant in producing these results.

On this test the schizophrenics appear as the most variable, the

TABLE 10

DATA OF THE DISTRIBUTION OF THE MEANS, PNEUMO ERGOGRAPH, TEST 3, FOR VARIOUS GROUPS FOR THREE SESSIONS (NO. OF PRESSURES IN 10 SEC.)

Group	N.	Maximum	Minimum	Range	Mean σm	S.D. σs.d.	V.
Normals	50	58.78	32.99	25.79	43.40±1.02	6.37± .64	14.71
Schizophrenics	23	41.89	22.11	19.78	32.07±1.69	7.91±1.17	24.66
Manic-Depressives	25	57.89	29.00	28.89	39.92±1.66	6.57± .93	16.46
(a) Manic	8	57.89	36.00	21.89	43.16±2.58	6.84±1.71	15.85
(b) Depressives	17	48.89	29.00	19.89	38.39±1.42	5.50± .82	14.33
Psychoneurotics	25	56.89	32.67	24.22	44.37±1.16	5.66± .80	12.76

manic-depressive group as a whole second, the manics alone third and the psychoneurotics the least, with the normals and the depressives falling between.

Test 4. Star Tracing

This test is regarded as sampling motor performance at a fairly high level of integration since it includes complex eye-hand coordination, speed, accuracy and steadiness of movement. There is no satisfactory way to combine the measures of time and errors into a composite score for simplification of interpretation. This being true the data have been treated separately, but in discussing the results the two factors will be treated together.

The test-retest reliabilities for both time and errors for all of the groups were well within satisfactory limits.

Performance differences in terms of time were most marked for the schizophrenics (Table 11). They required longer times on all trials than any other group and made more errors (Table 12) than all groups excepting the manics. The time difference was highly reliable and there were 89 chances in 100 of the differences in error being reliable when compared with the normals. The differences between all other groups and the schizophrenics were reliable on speed and close to being statistically reliable on errors.

The manic patients, on the other hand, were much faster in performance than any of the other groups and at the same time they made the greatest number of errors. The critical ratio of the difference between the manics and normals on time was 4.22, on errors, 3.56. The depressives required the second longest time for all trials, the chances being 95 in 100 of a reliable difference between their performance and the normals. They committed fewer errors than any other group excepting the psychoneurotics. The difference between them and normals on errors committed gave a reliability little better than chance. The manic-depressive group taken as a whole gave no reliable differences in speed over the normals. Due to the fact that the manics made the greatest number of errors, the combined errors of the manic-depressives when compared with normals had 97 chances in 100 of being a significant difference.

The differences between the normals and the psychoneurotics

TABLE 11

DATA OF THE DISTRIBUTION OF THE MEANS, STAR TRACING — TIME, TEST 4A, FOR VARIOUS GROUPS FOR THREE SESSIONS (IN SEC.)

Group	N.	Maximum	Minimum	Range	Mean σm	S.D. σs.d.	V.
Normals	50	37.06	8.43	28.63	18.27± .72	5.09± .51	27.86
Schizophrenics	23	32.24	18.36	13.88	23.71± .85	3.99± .59	16.83
Manic-Depressives	25	30.90	11.88	19.02	19.02±1.11	5.43± .77	28.55
(a) Manics	8	19.73	11.88	7.85	14.81± .41	1.09± .27	7.36
(b) Depressives	17	30.90	12.45	18.45	21.08±1.39	5.38± .92	25.52
Psychoneurotics	25	36.90	13.62	23.28	19.17±1.59	7.79±1.10	4.64

TABLE 12

DATA OF THE DISTRIBUTION OF THE MEANS, STAR TRACING — ERRORS, TEST 4B, FOR VARIOUS GROUPS FOR THREE SESSIONS

Group	N.	Maximum	Minimum	Range	Mean σm	S.D. σs.d.	V.
Normals	50	12.11	1.44	10.67	5.23±.38	2.72±.27	52.08
Schizophrenics	23	13.78	1.80	11.98	6.76±.59	2.77±.41	40.98
Manic-Depressives	25	12.22	1.56	10.66	6.29±.41	1.99±.28	31.64
(a) Manics	8	9.67	5.22	4.45	7.47±.50	1.32±.33	17.67
(b) Depressives	17	12.22	1.56	10.66	5.77±.49	1.91±.33	33.10
Psychoneurotics	25	9.11	1.67	7.44	4.34±.47	2.30±.33	52.00

were not great enough to be reliable on time, but their performance may be regarded as much better since they made the fewest number of errors.

Comparing the patient groups with each other it is evident that the differences in both time and errors were in most cases completely reliable. The day to day relationship of the curves of time and errors tend to remain constant except for the manic group.

All groups on all trials showed trial to trial decreases in time of performance except the manics on trial 3, session II, and trials 2 and 3, session III, and the schizophrenics on trial 2, session III. Session to session improvement in speed occurred in every group excepting the schizophrenics between sessions II and III.

It is interesting to note that a consistent reduction of time did not, however, carry with it either increase or decrease in number of errors committed to any significant amount. On sessions I and II there appears a reduction of errors between trials 1 and 2 and an increase in number of errors between trials 2 and 3. This is true for all groups except the manics in session II who showed an exaggerated increase in the number of errors made. In session III the picture is somewhat reversed, for there is an increase in errors between trials 1 and 2 and a decrease between trials 2 and 3, the final number on trial 3 being slightly lower than on any other trial. Again the manics gave contrary results for they started trial 1 with a large number of errors and gradually reduced them through trials 2 and 3.

Means for the three sessions for all groups show no significant changes toward error reduction from session I to III, although there are slight shifts in the curve, notably in the case of the manics who somewhat increased the number of errors from session I to II. This increase was reflected in the composite curve of the manic-depressive group.

Consideration of the factor of variability points to the fact that in terms of time the manic-depressive group gave the highest coefficient of variability; the normals second, depressives third, schizophrenics fourth, the manics and psychoneurotics in order.

Variability coefficients in terms of errors committed run high for all groups. The normals and psychoneurotics present the

highest variability; the schizophrenics third. The manics who committed the greatest number of errors showed the least variability.

The manics, who performed the fastest, made the greatest number of errors, but the schizophrenics who required the longest amount of time, instead of having fewest errors were close to the manics in number committed. This is an interesting observation in view of the fact that reduction in speed would be expected to reduce error. This generalization does not hold for this data as a whole.

Test 5. Reaction-coordination (Miles)

The speed with which an individual perceives a stimulus, and initiates and completes a coordinated series of movements as a response to the stimulus is a function of a high order in the hierarchy of adaptive acts. The integration of neuro-muscular coordinations involved in the process is exceedingly complex. The Miles reaction-coordination board was designed to measure the efficiency of motor reaction-coordination at this relatively complex level. Demonstrated differences between the mentally diseased and the normal showing significant modification in the patient's ability to perform relatively complex motor coordinations will have much value in indicating the ways in which the disease syndrome modifies personality.

Numerous investigators, among them Bevan-Lewis (5), Franz (14, 15), Yerkes (43), Wells and Kelley (39) and Lundholm (24), have studied simple reaction times in the mentally diseased. Dodge and Diefendorf (9) measured ocular reaction time to peripheral stimuli. Huston (20) and Shakow (35) investigated types of motor coordination. In general the results of these studies are not in agreement. The question regarding the nature of psychotic and psychoneurotic reaction times is still open.

However, there are two points which seem to be accepted by all of them; first, psychotics are highly variable in reaction time and, second, depressives show retardation. None of these studies were concerned with the more complex type of measure used in the present investigation, hence it is doubtful if the results are in any way comparable although they may be remotely related.

Test-retest reliabilities on the reach and grasp coordination for

all groups except the schizophrenic were acceptably high. In this one group we find $r = .58 \pm .09$. The low reliability coefficient is probably due to the variability of the subjects composing the group.

An extremely wide difference in speed of reaction-coordination was demonstrated between the schizophrenics and the normals (Table 13). Miles' mean scores for 25 normals using the dominant hand on the same test was 1.21 sec. (27). The mean of this larger group of normals, on a more extended number of trials, namely 30, may be regarded as identical. The mean score for the three sessions was 1.20 for the normals and 1.42 for the schizophrenics. The critical ratio ($D/\sigma D$) of the difference was 5.50. The mean scores for each session maintain the extreme difference in relationship.

The mean for the psychoneurotics was 1.21, the same as for Miles' normals and closely identical to the normal group in this study. Manics gave an expected increase in speed of reaction.

The most surprising results of the whole experiment were those of the depressed group on this test. This group gave faster reaction-coordination times than any of the others, the critical ratio ($D/\sigma D$) was 5.88 between their scores and the normals. This difference was so striking that the data were carefully rechecked for possible error, but none was found. Examination of the range shows it to be slightly smaller than the other groups but not noticeably so. Depressed patients have been known to show reduced reaction times. Franz (15), very early in the century, found anomalous choice reaction times in a depressed patient. In a second investigation (14), checking the finding, one of two depressed patients showed a reduction in choice reaction times. Thus there is some small precedent for the results obtained in this test. One possible explanation for these results may be that the patients used in this study were depressed mostly at the affective level, the physiological components of depression being at a minimum, since they were all capable of a fair degree of cooperation. In the test situation it may be that their interest in the test tended to release the depressed affect permitting them to perform at a normal level or better. It is also possible that some of these subjects had manic tendencies operating at the psychomotor level beneath the mild

TABLE 13

DATA OF THE DISTRIBUTION OF THE MEANS, REACTION-COORDINATION, (MILES) TEST 5, FOR VARIOUS GROUPS FOR THREE SESSIONS (IN SEC.)

Group	N.	Maximum	Minimum	Range	Mean σm	S.D. $\sigma s.d.$	V.
Normals	50	1.47	1.00	.47	$1.20 \pm .016$	$.11 \pm .011$	9.17
Schizophrenics	23	2.08	1.13	.95	$1.42 \pm .036$	$.17 \pm .025$	11.97
Manic-Depressives	25	1.36	.94	.42	$1.12 \pm .002$	$.10 \pm .013$	8.93
(a) Manics	8	1.36	.98	.38	$1.17 \pm .041$	$.11 \pm .027$	6.47
(b) Depressives	17	1.30	.94	.36	$1.10 \pm .001$	$.003 \pm .001$	.27
Psychoneurotics	25	1.45	1.03	.42	$1.21 \pm .006$	$.03 \pm .004$	2.48

depressive affective level. A third possibility is that the motivational factor was at a maximum in those patients who were on the upward swing of their cycle in the hope that good performance might more speedily bring their discharge from the institution. Exactly what the facts are to account for this heightened speed cannot be determined from the data. Yerkes (43) early pointed out that the times of reaction and the variability of these times within a single experiment might be employed as indicators of two separate functions (general readiness to respond and stability of attention, respectively). If his theory holds, we may say that the depressed patients appeared to be readier to respond, probably because the depression tends to narrow the field of consciousness, sharpen the focus of and hence stabilize attention.

Progressive reduction of reaction-coordination time occurred from session to session in the schizophrenics, psychoneurotics and normals. Neither the manics nor the depressives were able to reduce their time of reaction from session to session by a reliable amount. As a matter of fact the depressives slightly increased their time between session I and II.

On this test the schizophrenics were more variable in response than the other groups, whereas the depressives appear remarkably stable. Outside the depressed group the psychoneurotics show the least variability, the normals next to the most variability.

Tests 6 and 7. Rhythm, Regular and Irregular Patterns

Hunt (18) reports no titles in the literature on experimental psychopathology which deal with the problem of rhythm as a motor phenomenon. Two articles related to one aspect of the problem, namely, perseveration, have some bearing. Mays (25) and Shipley (36) both attempted to discover whether or not perseverative tendencies are demonstrable on the automatic level. Both studies used the galvanic skin response as an indicator of perseveration. Both studies ranked the psychotic groups higher on perseveration. But these studies are not comparable to the tests used in the present work. The serial presentation of patterns of sound stimuli acting as a pacing mechanism to be followed by the subject by tapping a key was, so far as we know, used for the first time as a test of motor function in the mentally diseased by Lindley (23). In a

more extended study on normals he included two patients, one a female hysteric, the other a male manic. Both were under the influence of drugs about the time of the experiment. Seashore (32) investigated motor rhythm in normals and devised a standard apparatus for this type of measurement as a part of the Stanford motor skills unit (33). Miles (26) has investigated the effects of instruction on tapping rate. He found that each of his twelve subjects had a "preferred" rate of tapping, but this rate was affected by a "set" for slow or fast tapping. Rhythmic tapping gave a smaller range of rates than non-rhythmic performance. Foley (13) has shown that speed and tempo of motor reaction are conditioned by specific environmental factors.

The present experiment attempted to control the environmental factor of set by the simple expedient of letting the subject hear the sound pattern once before he was expected to follow it. Thus he was in a state of expectancy for the regular pattern, the length of the rest interval and the irregular pattern. This was clearly demonstrated by the fact that many of the subjects anticipated by a small margin the onset of the stimulus pattern.

In evaluating the results of this test four measures were used: (1) the length of the interval of delay in starting to follow the pattern, (2) the length of the interval of perseveration of tapping beyond the cessation of the stimulus, (3) the number of taps the subject made in trying to follow the pattern, and (4) the temporal length of the separate pressures.

Intercorrelations between the four variables in the regular pattern with the same four variables in the irregular pattern were, for measure (1) $r = .87 \pm .02$, measure (2) $r = .45 \pm .07$, measure (3) $r = .86 \pm .03$ and, measure (4) $r = .90 \pm .02$. With the exception of measure (2) perseveration, they may be regarded as similar variables. The low r on variable (2) may have been due to the grouping of stimuli. Intercorrelations of the four measures (Table 8) with all other tests were consistently low. The extremes were $r = -.36 \pm .08$ to $r = .36 \pm .08$.

Reliabilities for the four measures on both patterns for all groups were computed (Table 4). On both patterns for measure (1) delay, all of the subject groups gave coefficients of $r = .79 \pm .03$ or greater. In the case of measure (2) perseveration, the

coefficients of reliability were fairly satisfactory for all groups except the normals on both patterns and the psychoneurotics on the irregular pattern. For the normals the reliabilities were r = .50±.07 regular pattern, irregular pattern r = .55±.06. The psychoneurotic patients gave a peculiar coefficient on the irregular pattern, r = .17±.13. At the present time the writer has no theory to account for this odd result.

Coefficients of reliability for measure (3) number of taps, on both patterns were within satisfactory limits with the exception that the schizophrenic group on the regular pattern were r = .55±.09.

On measure (4) length of pressure time, the reliabilities while not high are close to significance for all the groups but the schizophrenics, who on both patterns show low coefficients. For the regular pattern r = .47±.11, irregular pattern r = .41±.11.

Consideration of the various measures (Tables 14, 15, 16, 17 and 18, 19, 20, 21) is now indicated. In the first place the schizophrenic patients possessed a marked tendency to delay before following the pattern; they perseverated longer than the normals; their mean number of taps was lower than all of the groups; and the mean length of their pressure time was greater than the other groups excepting the depressed group. This was true for both the regular and irregular patterns. The critical ratios of the differences between them and normals exclusive of those for perseveration, were high enough to be reliable. Comparison of this group with the other patient groups indicates that the relationships mentioned above hold for all groups on the four measures with the one exception of perseveration on the irregular pattern. In this one case the schizophrenics' mean perseveration time was less than all the other groups but for the depressives. The critical ratio ($D/\sigma D$) of these differences was not notably high. Constancy from session to session cannot be attributed to the differences. It is evident from these data that the schizophrenics show a slowing down of ability to respond to external stimuli and a tendency to discontinue responding.

Combined data for the manics and depressives are given, but for the present purpose it is more to the point to consider the groups separately. On this test the differences between the manic

TABLE 14

DATA OF THE DISTRIBUTION OF THE MEANS, RHYTHM—REGULAR PATTERN—DELAY, TEST 6 A, FOR VARIOUS GROUPS FOR THREE SESSIONS (IN SECONDS)

Group	N.	Maximum	Minimum	Range	Mean σm	S.D. $\sigma s.d.$	V.
Normals	50	1.94	.24	1.70	.49±.047	.33±.033	67.35
Schizophrenics	23	1.34	.23	1.11	.65±.062	.29±.043	45.29
Manic-Depressives	25	1.57	.13	1.44	.50±.065	.32±.045	64.00
(a) Manics	8	.55	.13	.42	.25±.043	.11±.028	45.60
(b) Depressives	17	1.57	.38	1.19	.61±.083	.32±.054	52.46
Psychoneurotics	25	1.85	.15	1.70	.47±.062	.31±.043	65.96

TABLE 15

DATA OF THE DISTRIBUTION OF THE MEANS, RHYTHM—REGULAR PATTERN, PERSEVERATION, TEST 6 B, FOR VARIOUS GROUPS FOR THREE SESSIONS (IN SECONDS)

Group	N.	Maximum	Minimum	Range	Mean σm	S.D. $\sigma s.d.$	V.
Normals	50	1.03	—.71	1.74	.28±.026	.183±.018	65.36
Schizophrenics	23	.56	—.17	.73	.31±.044	.207±.03	66.13
Manic Depressives	25	.49	.05	.44	.24±.02	.10 ±.013	41.67
(a) Manics	8	.49	.19	.30	.36±.033	.089±.021	24.72
(b) Depressives	17	.27	.05	.22	.17±.004	.016±.002	9.41
Psychoneurotics	25	.84	.29	.55	.29±.027	.13 ±.018	44.83

TABLE 16

DATA OF THE DISTRIBUTION OF THE MEANS, RHYTHM—REGULAR PATTERN—NUMBER OF TAPS, TEST 6 C, FOR VARIOUS GROUPS FOR THREE SESSIONS

Group	N.	Maximum	Minimum	Range	Mean σm	S.D. σs.d.	V.
Normals	50	58.22	19.22	39.00	46.55± .94	6.67± .667	14.33
Schizophrenics	23	48.44	38.89	9.55	44.69± .63	2.94± .430	6.58
Manic-Depressives	25	53.22	37.34	15.88	47.60± .42	2.04± .288	4.29
(a) Manics	8	52.56	46.56	6.00	51.23± .78	2.06± .515	4.02
(b) Depressives	17	53.22	37.30	15.88	45.89± .88	3.42± .586	7.45
Psychoneurotics	25	34.33	22.30	12.08	45.19±1.50	7.34±1.030	16.24

TABLE 17

DATA OF THE DISTRIBUTION OF THE MEANS, RHYTHM—REGULAR PATTERN — PRESSURE TIME, TEST 6 D, FOR VARIOUS GROUPS FOR THREE SESSIONS (IN SECONDS)

Group	N.	Maximum	Minimum	Range	Mean σm	S.D. σs.d.	V.
Normals	50	.165	.04	.125	.085±.004	.03±.003	35.29
Schizophrenics	23	.15	.06	.09	.109±.004	.02±.002	18.35
Manic-Depressives	25	.18	.05	.13	.100±.020	.10±.014	100.00
(a) Manic	8	.09	.05	.04	.060±.007	.02±.004	33.34
(b) Depressives	17	.18	.05	.13	.140±.021	.08±.013	57.14
Psychoneurotics	25	.18	.04	.09	.075±.048	.24±.033	314.67

TABLE 18

DATA OF THE DISTRIBUTION OF THE MEANS, RHYTHM—IRREGULAR PATTERN — DELAY, TEST 7 A, FOR VARIOUS GROUPS FOR THREE SESSIONS (IN SECONDS)

Group	N.	Maximum	Minimum	Range	Mean σm	S.D. σs.d.	V.
Normals	50	2.39	.20	2.19	.44±.049	.35±.035	79.09
Schizophrenics	23	1.62	.16	1.46	.57±.058	.32±.047	56.14
Manic-Depressives	25	1.48	.14	1.34	.46±.061	.30±.042	65.22
(a) Manics	8	.44	.14	.30	.23±.036	.10±.024	42.61
(b) Depressives	17	1.48	.26	1.22	.57±.078	.30±.051	52.63
Psychoneurotics	25	1.41	.21	1.20	.40±.058	.34±.048	85.00

TABLE 19

DATA OF THE DISTRIBUTION OF THE MEANS, RHYTHM—IRREGULAR PATTERN—PERSEVERATION, TEST 7 B, FOR VARIOUS GROUPS FOR THREE SESSIONS (IN SECONDS)

Group	N.	Maximum	Minimum	Range	Mean σm	S.D. σs.d.	V.
Normals	50	.89	.20	.69	.42±.020	.14±.014	32.86
Schizophrenics	23	.70	—.14	.84	.38±.046	.22±.032	57.11
Manic-Depressives	25	.66	—.04	.70	.35±.020	.10±.014	28.57
(a) Manics	8	.66	.28	.38	.48±.045	.12±.030	25.00
(b) Depressives	17	.52	—.04	.56	.29±.044	.17±.029	58.62
Psychoneurotics	25	.82	.08	.74	.43±.006	.03±.004	6.98

TABLE 20

DATA OF THE DISTRIBUTION OF THE MEANS, RHYTHM—IRREGULAR PATTERN—NUMBER OF TAPS, TEST 7 C, FOR VARIOUS GROUPS FOR THREE SESSIONS

Group	N.	Maximum	Minimum	Range	Mean σm	S.D. σs.d.	V.
Normals	50	36.45	21.44	15.01	32.04±.269	2.61±.261	8.15
Schizophrenics	23	33.22	25.45	7.77	29.94±.607	2.85±.420	9.52
Manic-Depressives	25	37.00	27.67	9.33	31.84±.559	2.74±.387	8.61
(a) Manics	8	37.00	30.11	6.89	34.22±.870	2.30±.575	6.72
(b) Depressives	17	32.11	27.67	4.44	30.72±.364	1.41±.241	4.58
Psychoneurotics	25	53.78	22.45	31.33	31.59±.614	3.01±.425	9.53

TABLE 21

DATA OF THE DISTRIBUTION OF THE MEANS, RHYTHM—IRREGULAR PATTERN — PRESSURE TIME, TEST 7 D, FOR VARIOUS GROUPS FOR THREE SESSIONS (IN SECONDS)

Group	N.	Maximum	Minimum	Range	Mean σm	S.D. σs.d.	V.
Normals	50	.22	.04	.18	.092±.005	.034±.003	36.96
Schizophrenics	23	.15	.06	.09	.116±.001	.004±.001	3.45
Manic-Depressives	25	.18	.04	.14	.110±.071	.350±.049	318.18
(a) Manics	8	.08	.04	.04	.060±.060	.160±.040	266.67
(b) Depressives	17	.18	.05	.13	.130±.106	.410±.070	315.38
Psychoneurotics	25	.10	.04	.06	.082±.053	.260±.036	317.07

patients and all other groups are very clear cut. For both patterns the manics showed less delay in responding, greater perseveration, more taps and shorter pressure times. Not only does this hold for mean scores but for each session as well. The heightened psychomotor activity of the manic is clearly reflected in these results. The critical ratios ($D/\sigma D$) are high enough in most instances to be completely reliable.

The relative positions of the manics and the depressives is reversed for the four measures on both patterns. The depressives delayed longer than all groups except the schizophrenics on the regular pattern, they perseverated less on every session than any other group, they tended to make fewer taps than all groups but the schizophrenics and the psychoneurotics on the regular pattern, their pressure time exceeded every other group on every session. The critical ratios ($D/\sigma D$) of the differences between the depressives and the normals approach or reach statistical reliability with one exception, namely on the number of taps made in following the regular pattern. The differences between the depressives and the manics are reliable except for pressure time in the irregular pattern. Between the depressives and the schizophrenics the differences are highly reliable excepting those between delay and pressure time. While differences between the depressives and psychoneurotics are present they are not always as distinct as they are shown to be for other groups.

The high reliabilities and the marked differences obtained between the various groups both lead to the conclusion that this test is a valuable measuring device of patient differences in ability to make motor responses to complex auditory stimulus patterns.

Turning now to a consideration of variability among the groups, the indices are somewhat confusing for the various measures under analysis (Tables 14, 15, 16, 17 and 18, 19, 20, 21). Several negative statements can be made at once, namely, schizophrenics are not the most consistently variable of the groups subjected to this test. The normal group tends to be more consistently variable than the schizophrenics although it is difficult to apply a criterion of consistency of variability on these four measures. With this in mind it may be said that among the patients the psychoneurotic group tend to be most variable, the combined manic-depressives are

next most variable and the depressives alone probably least variable. From this evidence no conclusions may be drawn regarding variability as determined by this test.

Conclusions: The first and most obvious conclusion to be drawn from these data is that schizophrenia is a disease which reduces the ability of the patient to perform adaptive motor acts at the intermediate levels of integration. Other investigators have previously shown (19, 34) that modification in the schizophrenic's ability to perform at the simpler levels of coordination also takes place. A no less obvious correlate is that the degree of adequacy with which he executes adaptive movements is in some way diminished. It is as if the patient lacked the prerequisite physiological energy, or basic drive, or contact with reality, or perceptual capacity, to respond satisfactorily to stimuli which under normal conditions would elicit adequate response. Although it might be expected that increase in the complexity of the environmental demands upon the schizophrenic would elicit reactions characterized by a decrease in the adequacy of response, these data do not substantiate the prediction. It appears that the reduction in capacity to perform may possibly spread with considerable uniformity across the whole range of response mechanisms, i.e., it probably makes no difference how simple or complex the environmental demands may be.

Variation in ability and adequacy of performance ordinarily attributed to the schizophrenic, although present, was not shown to be a determining factor in the production of these results. It appears that those tests demanding speed and accuracy as two components of the same task tend to develop more variability than those in which the speed factor is not present. This is interesting in the light of the theory sometimes advanced that the disease is a product of the individual's inability to keep up with the world in which he lives. At any rate it appears that the pressure to perform at a high rate of speed when present as an element in adjustment to specific situations tends toward greater maladjustment of the personality. This is most clearly seen in the extremely slow time scores in star tracing coupled with high error scores. The failure of the schizophrenics to show perseverational tendencies may not have any significance, or, it may be evidence supporting

the notion that this type of patient tends to withdraw from the real situation. Lewin (22) has described this withdrawal mechanism as the process of "encysting" within the field.

Finally, it seems legitimate to generalize from the evidence in these data that the diagnostic type classification of patients probably has experimental validity. The subjects were chosen on the basis of their undisputed membership in a given diagnostic class. The performance of the members comprising each group tended to be typical of the other members of the group. Schizophrenics tend to give characteristic and specific types of response patterns in situations demanding motor expression which are clearly different from those of normals, manic-depressives and psychoneurotics. Manic-depressives also show differential types of reactions which are distinguishable not only from each other but from schizophrenic and normal responses as well. It is only when psychoneurotics and normals are compared that reliable differences do not appear.

Discussion of the manic-depressive group can be most easily handled by separating the two patient populations. This is justified by the fact that striking differences in motor function have been shown to exist between the two phases of the disorder. Gross psychomotor hyperactivity in the manic is a much observed clinical fact which is borne out by the results of these tests. The pressure of activity, the tendency toward inaccuracy of movement and the disposition to perseveration appear as consistent components of the manic's performance at these motor levels. The characteristic pattern of their responses as differentiated from the schizophrenic and the depressive leads easily to the hypothesis that the manic phase is really not a phase of the manic-depressive syndrome but is rather a condition peculiar in itself. This is not to imply the existence of a disease entity as something sustaining an absolute functional unity of identity. Rather it is implying that most diagnostic differentiation is done on the basis of symptomatology and that logically this method might be carried over in separating the phases as diagnostically distinct. Practically there is probably no point in this separation but from the experimental point of view it might simplify future investigation.

The problem of distinguishing between depressive and manic

is not a great one but the difficulty in identifying the manic from the schizophrenic is sometimes very far from easy. As a matter of fact the term schizo-manic has been applied to patients when the diagnosis was not clear. The results of these tests suggest that a battery of similar motor tests might be devised which would reliably differentiate between the two disease types, perhaps even when the diagnosis was doubtful.

Retardation as a symptom of the depressed person needed no experimental observation. Even at the level of finer motor movements the slowing down is distinctly observable without testing. While this fact is generally supported by this investigation the results on the reaction-coordination test deny the consistency of the pattern. The depressed subjects gave faster reaction-coordination scores than any other group of subjects. The most probable theory to explain this reversal is that there are certain events or conditions in the environment that are capable of breaking through the depression at the affective level. When this occurs retardation at the motor level is diminished or even abolished. Release from the depressed symptoms may then accentuate the motivational factor, the patients striving to retain the state of release as long as possible. In the clinical situation it is not uncommon to see depressed patients who are continually verbalizing the desire to find some way to throw off the weight of the depression. This seeking for release may easily fixate upon certain interest arousing situations in the environment, such as the reaction-coordination test, calling forth greater effort resulting in a readiness to respond and an accentuated stability of attention.

This odd reversal leads to the conclusion that whatever the theory to explain it there are probably stimuli in the environment which can, and sometimes do, break through the depression and that these stimuli may be experimentally discovered to the end that they may be controlled and applied in the techniques of therapy. This notion is borne out by the fact that the depressives in this study show a high degree of variability throughout the various tests.

Shipley (36) has shown that manic-depressives have a greater tendency to perseveration than normals. The present investigation finds this factor in the manic group but little evidence for it

among the depressives.

Finally, it may be concluded that there is an essential difference between the ways in which the psychosis and the psychoneurosis affects the individual. Performance of the psychoneurotic was approximately like that of the normal group. His disease or mental condition seems to have little influence on his ability to perform adaptive acts at the level of motor coordination. It is a temptation to point to the classical ideology which has said that the psychosis is truly an organogenic phenomenon while the psychoneurosis is psychogenic. Whether or not this is true has not been determined by this study, but it is clear that the psychotics show disturbed adaptive motor function and the psychoneurotics do not. It would be interesting and profitable to investigate experimentally the statement which could flow from the results of this study, namely, that where a patient shows disturbance of motor function at the intermediate levels of integration he is more likely to be psychotic than psychoneurotic. Psychoneurotics tend to be less variable than normals and psychotics in motor function, but the difference between them and normals is not reliable.

Discussion: Having established a number of differences between various of the groups on motor tests and procedures which are clearly dissimilar and which have a fairly high degree of reliability, it may be assumed that the differences are probably not due to chance. The question now arises regarding the factors which may account for the differences. There are three general factors which must be considered, namely (1) factors of subject selection which may have no relation to the mental disorder; (2) the effect of conditions related to the experimental situation; and (3) factors involving the specific conditions of the psychosis or psychoneurosis.

Beginning with the first of these three it is conceivable that factors such as intelligence, age, duration of the psychosis etc. might affect the scores. For example Miles (27) has shown in normals that efficiency in certain types of motor function decreases with age. In their studies on motor function in schizophrenia Shakow and Huston (34) have shown that their results were not noticeably affected by the factors of age, duration of the psychosis, and Barr ratings. Without attempting to determine experimentally the

influence of these factors this study undertook to control them through subject selection. As may be seen in Table 1, a rather wide distribution of subjects' ages was sought. This may also be said of the duration of the psychoses or psychoneuroses; i.e., the distribution in length of illness ranged from six months to fifteen years. Intelligence factors were fairly constant for all groups. Hence, we may conclude that these factors, if operating separately or in combinations, were held at a minimum.

With regard to the second of these possible causes of variation, i.e., factors in the experimental situation, the problem of motivation looms largest. So far as can be found, no objective means have been discovered for determining the degree or quality of motivation acting in a given test situation. Observation remains as the only means of evaluating this factor. Even at its best, the rating scale method achieves results little better than those gotten by careful clinical observation. For the reasons that such methods have little scientific validity and that they tend to complicate unnecessarily the experiment, it was decided to depend upon the overt willingness of the subject to participate in an ostensibly routine hospital procedure, and where the level of cooperation was observably low, to dismiss the subject. Conceivably the very nature of the disease process may determine the maximum level of cooperation possible to the patient just as it may limit the possibility of his being activated at all.

Thus the general pattern of the subjects used was one of tacit if not hearty cooperation. That there were fluctuations in the level of cooperation during specific test sessions is probably undeniable, but it is justifiable to assume that we have at our disposal no methods of measuring them. Undoubtedly much of this change would escape the most cautious rating scale observation. Huston, Shakow and Riggs (19) in the second study on motor function in schizophrenia have shown the cooperation factor to have little effect upon reaction time. It is to be concluded that while the level of cooperation probably has some effect upon performance of motor function it was not a factor of major importance in the work reported here.

There remains the third of the three possible causes of variation, namely the conditions of the disease process itself.

If the two factors of selection and experimental conditions have been successfully eliminated as causes for the variations shown by the patients we are left with the conclusion that there is some particular way in which the psychosis modifies the capacity of the individual as an adaptive organism to respond to stimuli. Although the modification is undoubtedly quantitative as well as qualitative we cannot be too sure that there is an actual reduction in capacity to respond. It may well be that, as Kahn and Cohen (21) have pointed out, the "way of experiencing" of the individual has been profoundly changed. In one sense we have measured some aspects of the subject's way of experiencing but this has not given us any better understanding of how it is that the psychotic experiences his world. Huston, Shakow and Riggs (19) have advanced and tested three hypotheses to explain the differences of psychotic performance. Although their explanations are ingenious and illuminating they remain only descriptions of observed behavior. They shed little light on the fundamental problem. The complexities of the problem will undoubtedly yield to an ingenious experimental attack. One possible approach may be opened through an investigation of "the way of experiencing" of the individual.

SUMMARY

(1) A comparative investigation was made of motor function at the level of the intermediate integrations. Seven different tests providing 14 measures were used. The estimation of known sizes, (1) the U.S. dollar bill, (2) the U.S. half dollar coin, (3) the pneumo-ergograph, (4) star-tracing, (5) reaction-coordination, (6) rhythm, regular pattern, (7) rhythm, irregular pattern.

(2) Four subject groups were used: 23 schizophrenics, 25 manic-depressives, 25 psychoneurotics, and 50 normals, a total of 123. All subjects participated in three thirty-minute sessions on consecutive days.

(3) Intersessional, test-retest correlations indicate high reliability. Inter-test correlations were consistently low, indicating the independent nature of the variables measured.

(4) Selection of subjects for age, duration of psychosis, intelligence and level of cooperation were used as a method of control.

(5) The schizophrenic group showed wide differences in their level of attainment on all tests when compared with normals and other patient groups. Their performance was consistently less adequate, but the degree of intersessional improvement was consonant with the normals. Variability was greatest on those tests involving speed of movement. Perseverational tendencies were not demonstrated.

(6) The data for the manic-depressive group were divided for purposes of analysis and interpretation. There were 8 manics and 17 depressives. Manics performed at higher speed levels than all other groups and tended to make more errors. Depressives reflected general psychomotor retardation except in reaction-coordination in which they were most proficient. Variability, while present in both groups, was not consistent for all tests. Manics show high perseverational tendencies; depressives do not.

(7) Psychoneurotics performed at about the same level as the normals. They showed greater tendency to perseverate and were less variable than the normals. Differences were unreliable.

(8) It is suggested that schizophrenia is a disease which reduces ability of patients to perform intermediate level motor tasks. As the level of complexity increases or decreases, his inability to perform adequately is roughly the same. Speed of adjustment and response is most notably affected.

(9) A further suggestion indicates the advisability of regarding, for experimental purposes, the manic phase and the depressed phase as separate classifications rather than as phases of a single disease syndrome.

(10) Certain environmental conditions having within them high interest arousing elements are capable of dispelling the motor components of depression. Situations eliciting marked interest and high motivation should be submitted to experimental control and investigation for purposes of discovering new cues looking toward a controlled therapy.

(11) There is some evidence in these data supporting the diagnostic type classification of patients. Tests of this general type are suggested as a means of distinguishing between schizophrenia, manic-depressive psychosis, and the psychoneuroses, where the diagnosis is difficult.

(12) Since motor function in psychotics is profoundly disturbed, and shows no significant changes in the psychoneurotic, it appears that the organogenic-psychogenic dichotomy has some validity.

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